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Molecular orientation in biomaterials is thought to be critical in characterizing the precursors of wear and the production of debris during the wear process. Current methods of inferring or deducing orientation are not accurate and often rely on staining specimens. Our objective is to use the electric field polarization dependence of soft x-ray absorption to determine if molecular orientation measurement in biomaterials is possible and to evaluate the utility of this technique.

A multi-axial wear tester was used to produce a uni-directionally rubbed (2000 cycles) ultra high molecular weight polyethylene sample (UHMWPE). Soft x-ray absorption was performed utilizing tunable monochromatic linearly polarized soft x-rays from U7A beam line coupled with an electron yield detector. By rotating the sample disk azimuthally the rubbing axis of the disk was aligned parallel to the plane containing the electric field vector of the linear polarized soft x-rays as shown in fig. 1. E-vector may be aligned parallel (solid curve, normal incidence) and perpendicular (dashed curve, glancing) to the sample. The soft x-ray absorption peak associated with C-C chain axis is maximized and the C-H peak is minimized in the parallel alignment and conversely when the electric field is perpendicular to the sample, then the soft x-ray absorption peak associated with C-C chain axis is minimized and the C-H peak is maximized. From the relative intensity changes of the C-C and C-H peaks we deduce that on average at least 90% of the polyethylene molecular chains are preferentially aligned parallel to the rubbing direction.

The NEXAFS spectra of the sample disk was rotated azimuthally aligning the rubbing axis of the disk perpendicular to the plane containing the electric field vector of the linear polarized soft x-rays is shown in fig. 2. The C-C and C-H intensity changes are nearly similar in normal and glancing incidence. This illustrates carbon soft x-ray absorption data for the above geometry shows the nearly isotropic behavior of the C-C and C-H peaks. From the relatively small intensity changes of the C-C and C-H peaks we deduce that on an average very few of the polyethylene molecular chains are aligned perpendicular to the rubbing direction.

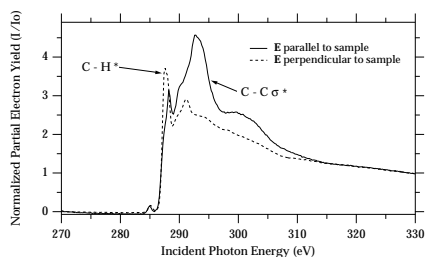


Figure 1. NEXAFS spectra of UHMWPE with rubbing axis parallel to plane containing E-vector

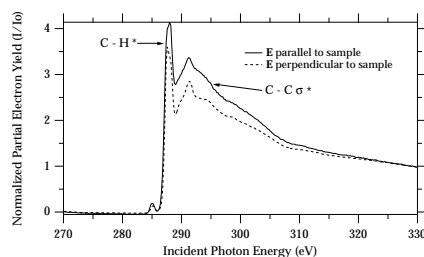


Figure 2. NEXAFS spectra of UHMWPE with rubbing axis perpendicular to plane containing E-vector